BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for performing resistance-type exercises and, more particularly, to a method and devices operable for changing the direction and magnitude of a resistive force in a cyclic manner multiple times during a single repetition of muscular contracture.

2. Prior Art

Resistance exercise devices are well known in the art. Resistance exercises normally involve the contraction of a muscle against an opposing resistive force to move a portion of the body through a range of motion. The contraction is usually repeated to include a plurality of cycles (repetitions) of motion of the body portion through the range of motion, which range is determined by the degree of muscular contraction and extension achieved during a repetition. The resistive force may be provided by gravity, as with weight training (barbells, dumbbells, pull-up and pull-down stacks of weights, etc.), or by an elastic force such as springs, bungees and the like.

Weight lifting is an exercise in which muscles are contracted against a resistance that is moved through a range of motion. The resistance is normally in the form of a weighted object that the user moves through either a flexion or extension of a body portion such as the arms or legs. In weight lifting, there are a number of exercises in which the user moves a weighted barbell in order to

strengthen his or her upper body muscles. One example of such an exercise is a bench press in which the individual initially assumes a supine position atop a support bench. The weightlifter then uses his or her arms to lift the barbell from a position just above the lifter's chest to a higher vertical position where the lifter's arms are fully extended. This exercise is normally accomplished without any sideways movement (abduction or adduction) of the lifter's hands. This basic exercise can be modified by inclining the support bench (inclined press) or by starting with the bar substantially coplanar with the user's torso (pull overs).

In the biomechanics of limb function, there one or more joints which contribute to the limbs functional motion. Each time the limb moves, motion takes place in one or more of these joints. Limb movement, such as movement of the arm, may include flexion, extension, abduction, adduction, circumduction, internal rotation, and external rotation. These movements are usually defined in relation to the body as a whole. Flexion of the shoulder is a forward movement of the arm. Extension, the reverse of this, is backward movement of the arm. Abduction is the movement of raising the arm laterally away from the body; adduction, the opposite of this, is then bringing the arm toward the side. Circumduction is a combination of all four of the above defined movements, so that the hand describes a circle. Internal rotation is a rotation of the arm about its long axis, so that the usual anterior surface is turned inward toward the body; external rotation is the opposite of this.

All movements of limbs, for example, the arm relative to the shoulder, can be described by the terms used above. It will be appreciated by the artisan that most movements of a limb such as the arm are combinations of two or more of the above defined movements. A plurality of muscles cross each limb joint. Their function is to create motion, and thus the ability to do work with the limb. To perform a given task with precision, power, endurance, and coordination, most, if not all, of these muscles must be well conditioned.

The function of each of these limb muscles depends on its relative position to the joint axis it crosses, the motion being attempted, and any external forces acting to resist or enhance motion of the limb. During limb motion, groups of muscles interact so that a desired movement can be accomplished. The interaction of muscles may take many different forms so that a muscle serves in a number of different capacities, depending on movement. At different times a muscle may function as a prime mover, antagonist, or a fixator or synergistically as a helper, a neutralizer or a stabilizer.

For example, consider flexion of the arm. There are three major joints which contribute to elbow function: the ulnar-humeral, radio-humeral, and the radio-ulnar. The ulnar-humeral is responsible for flexion and extension while the radio-humeral and the radio-ulnar joints are responsible for supination and pronation. Flexion is movement in the anterior direction from the position of straight elbow, zero degrees to a fully bent position such as a curl. Extension is

movement in a posterior direction from the fully bent position to the position of a straight elbow.

A plurality of muscles effect motion at each limb joint. For example, in the elbow, these include the Biceps brachii, the Brachialis and the Triceps brachii. These muscles are continually active as their role changes in performing the complex activities of daily living. Each muscle spanning a limb joint has a unique function depending on the motion being attempted. It is generally conceded that in order to fully train and strengthen limb musculature, it is necessary to work the limb in all planes and extremes of motion to optimize neuromuscular balance and coordination.

The types of limb exercise and/or exercise devices currently used in exercise programs generally include isometric, isotonic and isokinetic exercise. Isometrics is an exercise that is performed without any joint motion taking place. For example, pressing a hand against an immovable object such as a wall. When exercising a muscle group within a limb, strength can be improved only in the range of motion in which the limb is being exercised. Since in isometric exercises only one position and one angle can be used at one time, isometric exercise is time consuming if done correctly.

Isotonic exercises are done against a movable resisting force. The resisting force is usually free weights. Isotonic exercises are probably the most common method for exercising both the the upper and lower limbs as free weights are

relatively inexpensive to acquire and readily available in gyms. A weight is held in the hand and moved in opposition to gravity. It is a functional advantage to be able to move a limb through a full range of motion, but because of the unidirectional nature of gravity, the body position must be continually changed for all muscles to be exercised.

During a single repetition of isotonic weightlifting, the load remains constant but the amount of stress on the muscle varies. The most difficult point in the range is the initial few degrees with a movement to overcome inertia. As the upper extremity comes closer to the vertical position, work becomes easier due to improved leverage. This creates a noncyclic variability in the degree of muscle tension throughout the range of motion. Isotonic exercises can be performed on Nautilus and similar machines which achieve a more uniform resistance. A major disadvantage is that motion on these weightlifting machines is confined to a straight plane movement without deviation which does not replicate normal in-use movement of the limb.

Isokinetic exercise involves a constant speed and a variable resistance. Isokinetic exercise machines are currently limited to movement of a limb in one straight plane. The advantage of exercising a limb with an isokinetic device is that the resistive force can be bi-directional within the single plane of movement. Current isokinetic machines do not permit motion of the limb through different planes during a single repetition.

The particular muscle fibers involved in a contraction during a single repetition of resistive exercise depends upon the direction of the resistive force vector. If the resistive force vector is constant during a repetition, both directionally and in magnitude, as is the case with most prior art resistance exercise devices, only the muscles and portions of the muscle fibers within a muscle that are necessary to counter the resistive force will contract. Push-down/press-down ("PD2") types of exercise devices, such as, for example, disclosed in U.S. Patent Application Publication Number US2002/0068666 by Bruccoleri, have been further improved to include flexible members attached to a horizontal resistance bar. The flexible members are adapted to be grasped by the hands. In operation, the direction of the resistive force vector changes during a repetition such that different muscles and different muscle fibers within a muscle are exercised during the repetition. While the direction of the resistive force vector at the point of contact with the exercisor's body (i.e., the hands) changes during a repetition using PD2-type devices, the magnitude of the resistive force does not exhibit oscillations during a repetition. The prior art pull-down/press-down resistance type of exercise devices, such as the device shown in Figure 1, enable the user to exercise a plurality of muscles during a repetition because the plane of motion of the limbs varies during a repetition and it enables a full range of motion of the limb through a repetition. A disadvantage for this type of device is that the

vertical component of the resistive force F2 (Figure 1) is constant during a repetition.

It is desirable to provide a resistance exercise device wherein the direction of the resistive force oscillates in a cyclic fashion during a single repetition in order to increase the number of muscle fibers involved in the contraction over the number required when using a unidirectional device. There is also a need for a resistance exercise device wherein the magnitude of the resistive force oscillates over a plurality of cycles during a single repetition.

SUMMARY

It is an object of the present invention to provide a resistance exercise device operable for providing resistance to the movement of a muscle wherein the magnitude of the resistance oscillates for a plurality of cycles during contraction of the muscle that occurs while performing a single repetition.

It is a further object of the present invention to provide a resistance exercise device operable for providing resistance to the movement of a muscle wherein the direction of the resistance oscillates for a plurality of cycles during contraction of the muscle while performing a single repetition.

It is yet a further object of the present invention to provide a resistance exercise device operable for providing resistance to the movement of a muscle wherein both the direction and the magnitude of the resistance oscillates for a plurality of cycles during contraction of the muscle.

The features of the invention believed to be novel are set forth with particularity in the appended claims. However the invention itself, both as to organization and method of operation, together with further objects and advantages thereof may be best understood by reference to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view showing the movable portions of a pull-down/press-down type of exercise device in accordance with the prior art.

Figure 2 illustrates the resistive force vector provided by a prior art pull-down/press-down type of exercise device and the contractile force vectors applied by an exercisor that is required to overcome the resistive force vector.

Figures 3a-e are graphic representations illustrating examples of some of the possible oscillations in the magnitude F2 and/or the direction Φ of the resistive force vector during a single repetition in accordance with the present method. The range of motion during the repetition begins on the left and terminates on the right.

Figure 4 is an elevational side view of an angular oscillation lead pulley in accordance with a preferred embodiment of an exercise device of the present invention. The angular oscillation lead pulley is used to cyclically change the

direction of the resistive force vector F2 a plurality of times during the performance of a single repetition of exercise.

Figure 5 is an elevational side view of an angular oscillation lead pulley in accordance with another preferred embodiment of an exercise device of the present invention. The angular oscillation lead pulley is used to cyclically change the direction of the resistive force vector F2 nonuniformly and half as frequently during the performance of a single repetition of exercise than the lead pullet shown in Figure 4.

Figure 6 is an elevational view of a "bowtie" lead pulley in accordance with a second preferred embodiment of an exercise device of the present invention. The bowtie lead pulley simultaneously changes the leverage and thus the magnitude of F2 and the angular displacement Φ of the resistive force vector in an oscillatory manner during the performance of a single repetition.

Figure 7 is a schematic diagram of a pull-down/press-down device in accordance with an embodiment of the present invention employing a cam-like lead pulley having a smaller circumference than the preceding cam-like pulley wherein the magnitude of the resistive force F3 oscillates throughout the range of motion R during a repetition of the exercise.

Figure 8 is a graphical representation showing the change in the resistive force F3 throughout the range of motion R for the embodiment of the invention illustrated in Figure 7.

Figure 9 is a front view of a lead pulley suitable for use with a PD2-type of exercise device to cause the direction of the resistive force to oscillate wherein the plane of the lead pulley is tilted with respect to its axis of rotation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to Figure 1, a pull-down/press-down (PD2) device in accordance with the prior art is indicated in perspective view at numeral 10. For simplicity, only the moving parts of the PD2 device 10 are shown. In the device 10, a weight stack 11 is in mechanical connection to a handgrip 12 by means of a cable 13. The cable has a trailing end 13' attached to the weight stack 11 and a leading end 13'' attached to the handgrip 12. The cable 13 is supported by a rear pulley 14 and a lead pulley 15. The term "lead pulley" as used in the discussion of PD2 devices to follow, refers to the pulley supporting the cable that is closest to the leading end 13'' of the cable 13. The handgrip 12 may be a pair of handles connected to the free end 13'' of the cable by means of ropes or cables as shown, or it may comprise a bar, or similar grasping means.

If the rear pulley 14 has a circular groove 16, the resistive force F1 (a directional arrow in Figure 1) will be equal to the weight of the weight stack and oriented in the direction of the corresponding arrow. If the lead pulley 15 also has a circular groove 16', the resistive force vector F2 will be equal to F1 in magnitude. If the sum of the projections of applied force vectors F3 and F3' along

the axis defined by F2 is greater than resistive force F2, the weight stack 11 is lifted. When the applied forces F3 and F3' are relaxed, the weight stack returns to its original position until either the applied force F3 and F3' is reapplied, or it comes to rest on a support such as a floor (not shown) when the sum of the projections of F3 and F3' along the axis defined by F2 becomes less than F2.

The lead pulley 15 may be modified (Figures 4 and 5) such that when the lead pulley 15 turns as the cable 13 passes thereover, the lead pulley 15 changes the direction of F2 to displace the vector F2 through an angle Φ as shown in Figure 2. Figure 2 illustrates the resistive force vector F2 provided by a prior art pull-down/press-down type of exercise device and the applied force vectors F3 and F3' applied by an exercisor that is required to provide a resultant force vector F4 having a magnitude greater than the resistive force vector F2 in a direction opposite to F2. As the direction of F2 changes due to the displacement of the cable through an angle Φ, the projections of F3 and F3', F3v and F3'v, along the axis defined by the shifted direction of F2 will also change. The applied forces F3 and F3' must be changed by the exercisor in order to adapt to the fluctuating direction of F2. In order to adapt to the fluctuating (oscillating) direction of F2 during a repetition, the exercisor will need to contract more different muscles than are required with a constant F2.

The angle of displacement Φ and the magnitude of F2 can be made to oscillate during a repetition. Some examples of the change in magnitude and

direction of F2 that are possible with particular lead pulley constructions, as will be discussed below, are shown in Figures 3a-e. Figure 3a illustrates a sinusoidal fluctuation in either the magnitude or direction (or both) of F2 that occur during a single repetition. Figure 3b shows sawtooth fluctuations. Figure 3c illustrates a train of narrow pulses whereas Figure 3d illustrates a square wave. Figure 3e shows a modified sawtooth fluctuation in the magnitude and/or direction of F2 during a single repetition.

Various means such as mechanical, hydraulic or pneumatic devices may be employed to vary the direction and/or magnitude of the resistive force F2 in an oscillatory manner over a plurality of cycles during a repetition. Mechanical design of the lead pulley is a simple effective means for accomplishing such changes. Figure 4 is an elevational view of an angular oscillation lead pulley 40 in accordance with a preferred embodiment of a PD2 exercise device of the present invention. The angular oscillation lead pulley 40 is used to cyclically change the direction of the resistive force vector F2 a plurality of times during the performance of a single repetition of exercise. This is accomplished by forming the cable groove 16 in a cylindrical member 41 such that as the cylindrical member 41 turns about its axis of rotation A, the uppermost portion 42 of the groove 16, which supports and guides the cable (the cable is not shown in Figure 4), travels laterally in an oscillatory manner, returning to its starting position with every complete rotation of the cylindrical member 41. The cylindrical member 41

has a diameter D. The pulleys 40, 50 and 60 are all rotatably mounted and supported on the PD2 device by means of a cylindrical axle (not shown) affixed to the cylindrical member 41 coaxially with the axis of rotation A.

Figure 5 is an elevational side view of an angular oscillation lead pulley 50 in accordance with another preferred embodiment of an exercise device of the present invention. The angular oscillation lead pulley 50 is used to cyclically change the direction of the resistive force vector F2 irregularly and half as frequently during the performance of a single repetition of exercise than the lead pulley 40 shown in Figure 4.

The lead pulley designs presented above are suitable for providing a resistive force F2 that oscillates in direction during the performance of an exercise repetition. Figure 6 is an elevational view of a "bowtie" lead pulley in accordance with a second preferred embodiment of an exercise device of the present invention. The bowtie lead pulley 60 has a variable diameter D over the portion of the cylindrical member 41traversed by the groove 16 and simultaneously changes the leverage and thus the magnitude of F2 and the angular displacement Φ of the resistive force vector in an oscillatory manner during the performance of a single repetition.

The frequency of oscillation of the magnitude and/or direction of the resistive force F2 depends upon the particular lead pulley design and the speed at which the lead pulley rotates about the rotational axis A during the performance

of a repetition. The number of cycles in the change of direction and/or magnitude in the resistive force F2 that occurs during a repetition depends on the number of rotations the lead pulley makes during a repetition. It is obvious that for a lead pulley having the groove design illustrated in Figures 4-6, a cylindrical member 41 having a small diameter D will provide more oscillations during a repetition than a lead pulley having a greater diameter D. Accordingly, in accordance with the goal of the present invention, it is desirable to select D such that the lead pulley rotates a plurality of times during a repetition.

Figure 7 is a schematic diagram of a pull-down/press-down device 70 in accordance with a double cam-pulley embodiment of the present invention. The device 70 employs a cam-like lead pulley 15 having a smaller circumference than the preceding cam-like pulley 71wherein the magnitude of the resistive force F3 oscillates throughout the range of motion R during a repetition of the exercise. Figure 8 is a graphical representation showing the change in the resistive force F3 throughout the range of motion R for the embodiment of the invention 70 illustrated in Figure 7.

With continued reference to the PD2 device 70 of Figure 7, the lead pulley 15 may be cam-shaped and orthogonally mounted on its rotational axis 15a as shown or it may be tilted on its rotational axis 15a. If the plane of the lead pulley 15 is tilted with respect to its rotational axis 15a, the resistive force F3, shown in Figure 8 for an orthogonally mounted lead pulley, it will be appreciated by the

artisan that the resistive force F3 will further have an oscillating component in and out of the plane of the paper (not shown) that is orthogonal to a plane defined by the resistive force vectors F1 and F2. Figure 9 is a front view of a lead pulley suitable for use with a PD2-type of exercise device that is operable for causing the direction of a component of the resistive force to oscillate in and out of the plane of the paper (Figure 7). The plane P of the lead pulley 15 is tilted by an angle θ with respect to its axis of rotation A. In addition to being tilted, the lead pulley 15 may also be cam-shaped to provide oscillatory changes in both the direction and the magnitude of the resistive force during a single repetition.

The method for performing an exercise using the devices described above requires that the muscle(s) being exercised adapt to a fluctuating resistive force a plurality of times during a repetition. The adaptation requirement provides means for strengthening more cooperating muscles during a repetition than is possible when countering a constant resistive force. The method and device of the present invention enables the noncontiguous innervation of muscles during a repetition. It is noted that the muscles involved in a repetition "learn" how to adapt if the cyclic variations in the resistive force occur synchronously during each repetition. It is, therefore, desirable to design the exercise device such that the rotational orientation of the lead pulley at the beginning of each repetition is different than the orientation of the lead pulley at the beginning of the previous repetition.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. For example, as mentioned hereinabove, a variety of means such as pneumatic or hydraulic pumps and programmable controllers therefore, as well as specially designed lead pulleys as described hereinabove can be employed to cause the resistive force to oscillate in magnitude and/or direction during a repetition. With the use of programmable computer means, the waveform and/or the frequency of oscillations in the resistive force can also be made to fluctuate either in a predictable pattern or a randon fashion during a repetition. Further, although the invention has been presented using a PD2 device as an example of a device embodying the principles of the method, other resistance-type exercise devices employing an oscillating reistive force during a repetition are contemplated. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What I claim is: